1D Heterostructures – Simulation Exercise

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It is well known that in the design of HEMTs it is preferred to use delta doping in the buffer layer instead of homogeneous doping for two reasons: (1) Better control of the sheet electron density in the channel and (2) larger sheet electron densities can be achieved with delta doping. This exercise is designed to demonstrate this point using the 1D Heterostructure lab. To prove these points use the following two geometries:

Geometry 1: Cap layer is GaAs with thickness of 10 nm and doping of 10^{18} cm^{-3}. The buffer layer is AlGaAs layer that is 30 nm thick and the doping of this layer is also 10^{18} cm^{-3}. The underlying GaAs substrate is 55 nm thick and the substrate doping is 10^{14} cm^{-3}.

Geometry 2: Cap layer is GaAs with thickness of 10 nm and doping of 10^{18} cm^{-3}. The buffer AlGaAs layer is 30 nm thick and the doping of this layer in this case in 10^{14} cm^{-3}. There are two delta-doped layers, one at 35 nm from the top interface with sheet density 10^{12} cm^{-2} and the second one at 35 nm from the top interface with sheet density 2×10^{12} cm^{-2}. The underlying GaAs substrate is 55 nm thick and the substrate doping is 10^{14} cm^{-3}.

What is the gate voltage dependence of the sheet electron density for Geometry 1 and Geometry 2? Can you explore additional possibilities with Geometry 2 to get even higher sheet electron density?